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the **Large Hadron Collider** project

LHC Project Document No. **LHC-LQX-TP-0001 rev. 0.1**	*CERN Part Identifier (19 chars)* HCLQXB_001-FL000001
CERN Div/Group or Supplier/Contractor Doc No **TD/FNAL/USA**	*Test Procedure Number* LQXB_Test_Plan
EDMS Document No. **408010**	

Nonconformity Report

IDENTIFICATION	
1. Originator's Name: Phil Schlabach	6. Date: 22-Jan-2004
2. Contractor/Supplier: Fermilab	7. Part description: LQXB (Q2) Inner Triplet
3. Contract No: N/A	8. Qty: 1
4. Project Engineer: Jim Kerby	9. Dwg No: 5520-ME-390206 rev. C
5. Quality Manager: Jamie Blowers	

10. Found during what activity:

- ☐ Incoming inspection
- ☐ In-process inspection
- ☒ Final inspection
- ☐ Other:

11. Description of nonconformity (use continuation page if necessary)

The cold alignment is out of the tolerance defined in section 2.2.8 of the Acceptance Plan (reference section 2.1 of LHC-LQX-ES-0006). Between cold masses the relative pitch is -0.23 mrad (specification is 0.10 mrad) and relative yaw is 0.17 mrad (specification is 0.10).

12. Action taken to prevent misuse (use continuation page if necessary)

None.

IMPORTANCE

13. ☒ Non critical ☐ Critical

DISPOSITION

14. ☒ Use-as-is ☐ Repair ☐ Reject ☐ Rework ☐ Return to supplier

Description of proposed action (use continuation page if necessary)

According to the AP models, the LHC should be insensitive to this, and so we believe the magnet should be used as-is. See continuation page for further details.

CORRECTIVE/PREVENTIVE ACTION

15. Description of proposed action (use continuation page if necessary)

Alignment on this magnet has been optimized. We continue to run tests and studies to improve this in future magnets.

APPROVAL OF NON CRITICAL NONCONFORMITIES

16	Project Engineer: Jim Kerby	Date: 15-Mar-2004

APPROVAL OF CRITICAL NONCONFORMITIES

17	Project Management:	Date:

CLOSURE OF THE NONCONFORMITY

Planned actions have been completed and corrective/preventive actions have been initiated

	For non critical nonconformities Quality Manager or Project Engineer	For critical nonconformities Project Engineer
18	Name: Jamie Blowers Date: 15-Mar-2004	Name: Date:

NONCONFORMITY CONTINUATION PAGE

Section 14 continuation:

Physical Aperture in LQXB01 with measured offsets

The physical aperture (or geometric acceptance) in the low and high luminosity IRs was calculated using the alignment data from LQXB01. Lattice functions and the closed orbit were obtained from LHC lattice version 6.2 at collision and from LHC lattice version 6.4 at injection. We followed the definition and computation method used in Ref.[1]. The physical aperture is calculated on the basis of the largest secondary halo that can be inscribed in the vacuum chamber, taking into account the displacement of the beam at a particular point.

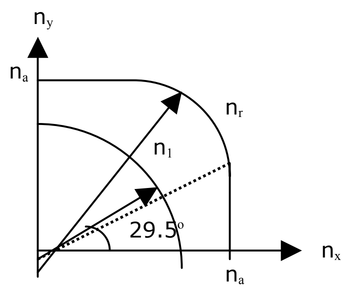


Fig. 1 The geometrical edge of the secondary halo

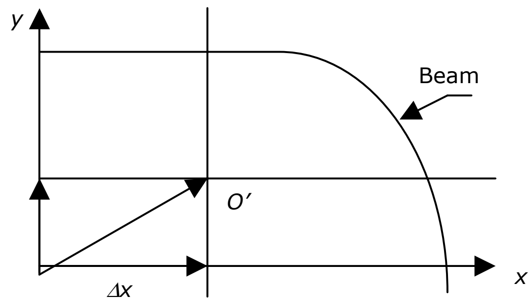


Fig. 2 Fit of the largest secondary halo in the vacuum chamber with the beam displaced by Δx,y with respect to the ideal center of the chamber

The primary collimators of the machine are at the distance n_l in the n_x-n_y plane, and define the primary aperture. The secondary halo is defined by n_r/n_l=1.4, as seen in Fig. 1.
The maximum beam displacement is calculated as follows (see Fig. 2)

$$\Delta_z = CO\_err + abs(z_{co} + z_{offset}) + \delta_z^{align} + k_\beta \cdot D_z \cdot \delta_p, \qquad z = x, y$$

where *CO_err* is the maximum closed orbit error taken to be 2.8mm (the value used in LHC Note188), z_{co} is the closed orbit excursion obtained from LHC lattice version 6.2, z_{offset} is the offset of Q2 from LQXB01. δ_z^{align} =1.6/√2 mm is the alignment tolerance of the vacuum chamber in the plane. Here we have assumed that the probably of an alignment error is equally likely in both planes and assigned them the same weight. k_β=1.1 is beta beating coefficient, D_z is the dispersion, and δ_p=(1.x10^{-3}, 2x10^{-4}) is the rms momentum spread at (injection, collision) respectively.The secondary halo n_r is calculated from the maximum beam ellipse that can be inscribed within the aperture set by the beam screen. Beam screen size used here was obtained from Nikolai Mokhov: $x_{beamscreen}$=30.1mm, $y_{beamscreen}$=25.3mm for IP5 and IP8, and $x_{beamscreen}$ =25.3mm, $y_{beamscreen}$ =30.1mm for IP1 and IP2.

Tables 1 and 2 list the physical aperture (geometric acceptance) n_l in *x* and *y* plane at collision (Red color means that the aperture in this plane is smaller), and Table 3 and 4 list the physical apertur at injection, which are calculated for low luminosity IRs (IP2 & IP8) and high luminosity IRs(IP1&IP5) in three cases.

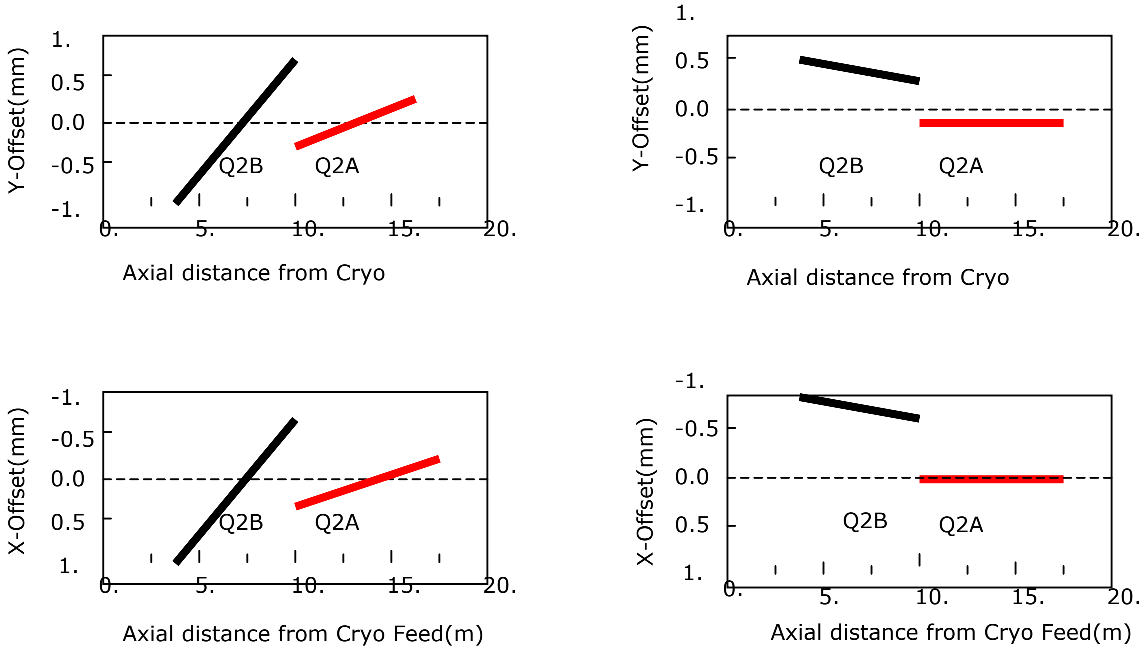
- Case 1 (the left column of Fig. 3): Q2A-Q2B axes relative to Q2a-Q2b Ave (measured 20 Feb03, at 4.5 ^{o}K in the 2nd thermal cycle TC2, AC);
- Case 2 (the right column of Fig.3): Q2A-Q2B axes relative to SSW (measured 09 Dec02, 4.5 ^{o}K, TC1)
- Case 0: with no offset.

The offsets listed in the table are the measured data.
The related beta functions, closed orbit excursions, dispersions and calculated r.m.s beam size are also listed in the tables.

The minimum physical aperture obtained at collision in high luminosity IRs is above 9σ, which is 2σ larger than the nominal primary aperture of n_l=7.0. The minimum physical aperture obtained at injection in low luminosity IRs is above 8σ, which is 1σ larger than the nominal primary aperture of n_l=7.0.

Reference

[1] J.B. Jeanneret and R.Ostojic, Geometrical acceptance in LHC Version 5.0. LHC project Note 111, 15 September 1997.



(a) Case 1 (b) Case 2

Fig. 3 LQXB01 Alignment: Q2A-Q2B axes relative to Q2a-Q2bAve (dotted line)

Right side of the IP			β_x (m)	β_y (m)	x_{co} (mm)	y_{co} (mm)	Dx (m)	Dy (m)	Case1			Case2			Case 0: No Offsets
									Offset		n1(≥7.)	Offset		n1(≥7.)	n1(≥7.)
									x (mm)	y (mm)		x (mm)	y (mm)		
IP2	Beam1	Q2A(1)	197.0	58.7	1.878	-3.494	.225	.002	-.082	.106	46.2	.002	.011	46.3	46.2
		Q2A(2)	260.4	59.7	2.171	-3.583	.259	-.011	.082	-.106	39.5	-.004	.015	39.4	39.5
		Q2B(2)	265.0	67.0	2.196	-3.817	.262	-.018	-.538	.743	40.9	-.858	.727	40.2	39.1
		Q2B(1)	217.6	102.9	2.000	-4.763	.237	-.034	.538	-.743	45.9	-1.011	.922	42.4	43.6
	Beam2	Q2A(1)	58.7	197.1	-1.037	6.318	.170	-.155	-.082	.106	48.4	.002	.011	48.0	48.4
		Q2A(2)	59.6	260.5	-1.064	7.306	.164	-.183	.082	-.106	43.0	-.004	.015	43.4	43.1
		Q2B(2)	66.9	265.2	-1.133	7.389	.170	-.187	-.538	.743	38.8	-.858	.727	39.2	41.3
		Q2B(1)	102.8	217.7	-1.414	6.728	.202	-.172	.538	-.743	37.3	-1.011	.922	42.2	40.2
IP8	Beam1	Q2A(1)	198.0	58.3	6.412	0.000	.043	.038	-.082	.106	49.4	.002	.011	49.4	49.4
		Q2A(2)	261.7	59.1	7.431	0.000	.043	.053	.082	-.106	44.0	-.004	.015	43.7	44.0
		Q2B(2)	266.1	66.3	7.518	0.000	.041	.064	-.538	.743	43.3	-.858	.727	42.6	42.2
		Q2B(1)	217.6	101.9	6.845	0.000	.033	.093	.538	-.743	42.5	-1.011	.922	39.7	41.5
	Beam2	Q2A(1)	58.3	197.9	-3.545	0.000	-.134	.158	-.082	.106	50.5	.002	.011	50.2	50.5
		Q2A(2)	59.0	261.6	-3.660	0.000	-.145	.178	.082	-.106	43.9	-.004	.015	43.7	43.9
		Q2B(2)	66.2	266.0	-3.912	0.000	-.157	.178	-.538	.743	42.1	-.858	.727	42.0	43.6
		Q2B(1)	101.8	217.5	-4.911	0.000	-.202	.158	.538	-.743	46.1	-1.011	.922	46.5	48.2

Table 1. Physical aperture for low luminosity IRs at collision

Notation:

Q2A(1)/Q2B(1) represent the offsets of the far ends of Q2A and Q2B
Q2A(2)/Q2B(2) represent the offsets at the weld end of Q2A and Q2B.

Right side of the IP			β_x (m)	β_y (m)	x_{co} (mm)	y_{co} (mm)	Dx (m)	Dy (m)	Case1 Offset x (mm)	Case1 Offset y (mm)	Case1 n1(≥ 7.)	Case2 Offset x (mm)	Case2 Offset y (mm)	Case2 n1(≥ 7.)	Case 0: No Offsets n1(≥7.)
IP 1	Beam1	Q2A(1)	1164.2	3406.2	-0.003	5.892	-0.524	0.742	-.082	.106	11.8	.002	.011	11.7	11.8
		Q2A(2)	1264.6	4559.8	-0.003	6.755	-0.546	0.858	.082	-.106	10.3	-.004	.015	10.3	10.3
		Q2B(2)	1442.2	4710.7	-0.004	6.839	-0.583	0.872	-.538	0.743	9.3	-.858	.727	9.3	9.8
		Q2B(1)	2222.7	4082.8	-0.004	6.314	-0.725	0.813	0.538	-.743	8.9	-1.011	.922	9.7	9.5
	Beam2	Q2A(1)	3403.1	1164.6	0.000	-3.383	1.548	-0.217	-.082	.106	12.2	.002	.011	12.1	12.2
		Q2A(2)	4555.7	1265.1	0.000	-3.414	1.792	-0.228	.082	-.106	10.5	-.004	.015	10.5	10.5
		Q2B(2)	4706.5	1442.8	0.000	-3.596	1.821	-0.244	-.538	0.743	9.9	-.858	.727	10.0	10.3
		Q2B(1)	4079.1	2223.5	0.000	-4.364	1.696	-0.304	0.538	-.743	10.6	-1.011	.922	10.8	11.1
IP 5	Beam1	Q2A(1)	1164.1	3405.8	-3.378	0.001	-0.383	-0.414	-.082	.106	12.2	.002	.011	12.1	12.2
		Q2A(2)	1264.5	4559.3	-3.409	0.002	-0.401	-0.477	.082	-.106	10.5	-.004	.015	10.5	10.5
		Q2B(2)	1442.1	4710.3	-3.591	0.002	-0.429	-0.484	-.538	0.743	10.0	-.858	.727	10.0	10.3
		Q2B(1)	2222.5	4082.4	-4.358	0.001	-0.534	-0.449	0.538	-.743	10.6	-1.011	.922	10.7	11.1
	Beam2	Q2A(1)	3403.1	1164.6	5.895	0.000	1.015	0.291	-.082	.106	11.8	.002	.011	11.8	11.8
		Q2A(2)	4555.7	1265.1	6.758	0.000	1.175	0.302	.082	-.106	10.3	-.004	.015	10.2	10.3
		Q2B(2)	4706.5	1442.8	6.843	0.000	1.194	0.321	-.538	0.743	10.0	-.858	.727	9.9	9.8
		Q2B(1)	4079.1	2223.5	6.318	0.000	1.113	0.397	0.538	-.743	9.8	-1.011	.922	9.1	9.5

Table 2. Physical aperture for high luminosity IRs at collision

Notation:

Q2A(1)/Q2B(1) represent the offsets of the far ends of Q2A and Q2B
Q2A(2)/Q2B(2) represent the offsets at the weld end of Q2A and Q2B.

Right side of the IP			β_x (m)	β_y (m)	x_{co} (mm)	y_{co} (mm)	Dx (m)	Dy (m)	Case1			Case2			Case 0: No Offsets
									Offset		n1(≥7.)	Offset		n1(≥7.)	n1(≥7.)
									x (mm)	y (mm)		x (mm)	y (mm)		
IP2	Beam1	Q2A(1)	191.2	59.1	2.822	-4.912	0.107	0.	-.082	.106	11.3	.002	.011	11.4	11.3
		Q2A(2)	270.1	59.7	3.291	-5.051	0.126	0.	.082	-.106	9.3	-.004	.015	9.2	9.3
		Q2B(2)	272.1	63.0	3.293	-5.203	0.126	0.	-.538	.743	9.7	-.858	.727	9.5	9.2
		Q2B(1)	211.1	106.9	2.845	-6.838	0.111	0.	.538	-.743	11.3	-1.011	.922	10.4	10.7
	Beam2	Q2A(1)	59.1	191.2	-1.405	8.718	-0.043	0.	-.082	.106	10.8	.002	.011	10.7	10.8
		Q2A(2)	59.7	270.1	-1.171	10.439	-0.037	0.	.082	-.106	9.1	-.004	.015	9.2	9.1
		Q2B(2)	63.0	272.1	-1.160	10.490	-0.037	0.	-.538	.743	8.3	-.858	.727	8.4	8.9
		Q2B(1)	106.9	211.1	-1.267	9.299	-0.041	0.	.538	-.743	8.2	-1.011	.922	9.5	9.0
IP8	Beam1	Q2A(1)	191.9	58.7	-8.721	-1.425	-0.082	0.	-.082	.106	10.8	.002	.011	10.8	10.8
		Q2A(2)	271.2	59.1	-10.410	-1.259	-0.095	0.	.082	-.106	9.1	-.004	.015	9.1	9.1
		Q2B(2)	273.1	62.4	-10.454	-1.262	-0.095	0.	-.538	.743	8.6	-.858	.727	8.8	8.9
		Q2B(1)	210.8	105.9	-9.217	-1.466	-0.084	0.	.538	-.743	8.7	-1.011	.922	9.0	9.0
	Beam2	Q2A(1)	58.7	191.9	4.882	2.854	0.049	0.	-.082	.106	11.3	.002	.011	11.2	11.3
		Q2A(2)	59.1	271.2	4.969	3.382	0.051	0.	.082	-.106	9.2	-.004	.015	9.3	9.2
		Q2B(2)	62.4	273.1	5.111	3.393	0.053	0.	-.538	.743	8.8	-.858	.727	8.8	9.2
		Q2B(1)	105.9	210.8	6.681	2.970	0.069	0.	.538	-.743	10.1	-1.011	.922	11.1	10.7

Table 3. Physical aperture for low luminosity IRs at injection

Notation:

Q2A(1)/Q2B(1) represent the offsets of the far ends of Q2A and Q2B
Q2A(2)/Q2B(2) represent the offsets at the weld end of Q2A and Q2B.

Right side of the IP			β_x (m)	β_y (m)	x_{co} *(mm)*	y_{co} *(mm)*	*Dx (m)*	*Dy (m)*	Case1			Case2			Case 0: No Offsets
									Offset		n1(≥7.)	Offset		n1(≥7.)	n1(≥7.)
									x (mm)	*y (mm)*		*x (mm)*	*y (mm)*		
IP1	Beam1	Q2A(1)	42.2	121.4	-1.868	6.329	-0.020	0.	-.082	.106	14.7	.002	.011	14.6	14.7
		Q2A(2)	41.9	167.1	-1.677	7.356	-0.013	0.	.082	-.106	13.0	-.004	.015	13.1	13.0
		Q2B(2)	43.8	168.8	-1.680	7.381	-0.012	0.	-.538	0.743	12.1	-.858	.727	12.2	12.8
		Q2B(1)	70.2	138.5	-1.915	6.617	-0.008	0.	0.538	-.743	11.7	-1.011	.922	13.1	12.5
	Beam2	Q2A(1)	121.4	42.2	3.410	-3.805	-0.050	0.	-.082	.106	13.7	.002	.011	13.8	13.7
		Q2A(2)	167.1	41.9	3.981	-3.730	-0.063	0.	.082	-.106	11.3	-.004	.015	11.3	11.3
		Q2B(2)	168.8	43.8	3.998	-3.799	-0.064	0.	-.538	0.743	11.8	-.858	.727	11.6	11.3
		Q2B(1)	138.5	70.2	3.600	-4.678	-0.060	0.	0.538	-.743	13.4	-1.011	.922	12.3	12.7
IP5	Beam1	Q2A(1)	42.2	121.4	3.803	3.415	-0.037	0.	-.082	.106	13.7	.002	.011	13.7	13.7
		Q2A(2)	41.9	167.1	3.723	3.999	-0.027	0.	.082	-.106	11.3	-.004	.015	11.4	11.3
		Q2B(2)	43.8	168.8	3.792	4.017	-0.026	0.	-.538	0.743	10.8	-.858	.727	10.8	11.3
		Q2B(1)	70.2	138.5	4.664	3.627	-0.023	0.	0.538	-.743	12.0	-1.011	.922	13.2	12.7
	Beam2	Q2A(1)	121.4	42.2	-6.328	-1.873	-0.046	0.	-.082	.106	14.7	.002	.011	14.7	14.7
		Q2A(2)	167.1	41.9	-7.350	-1.697	-0.058	0.	.082	-.106	13.0	-.004	.015	13.0	13.0
		Q2B(2)	168.8	43.8	-7.375	-1.703	-0.059	0.	-.538	0.743	12.5	-.858	.727	12.7	12.8
		Q2B(1)	138.5	70.2	-6.608	-1.958	-0.059	0.	0.538	-.743	12.2	-1.011	.922	12.9	12.5

Table 4. Physical aperture for high luminosity IRs at injection

Notation:
Q2A(1)/Q2B(1) represent the offsets of the far ends of Q2A and Q2B
Q2A(2)/Q2B(2) represent the offsets at the weld end of Q2A and Q2B.

INSTRUCTIONS FOR COMPLETING THE NONCONFORMITY REPORT

1. Originator	Name of the person who identifies the nonconformity
2. Contractor/Supplier	Organisation where the nonconformity is detected
3. Contract No	CERN's contract or order No
4. Project Engineer	Name of the CERN or Institute engineer in charge of the contract
5. Quality Manager	Name of the person responsible for quality control
6. Date	Date when the nonconformity is identified
7. Part description	Name of the part such as it appears on drawing or contract or order
8. Qty	Number of parts or lots affected
9. Dwg No	Part drawing number and revision index
10. Found during what activity	Tick the appropriate box. If ticking *Other* explain the circumstances
11. Description of the nonconformity	Describe the problem, identify the requirements that are not met, give references to specifications, procedures etc. If possible describe the possible causes of the nonconformity, such as inadequate procedure, wrong test set-up and so on.
12. Action taken to prevent misuse	Describe what steps have been taken to ensure that the item is segregated from the normal production while the nonconformity remains unresolved.
13. Importance	P.E. to decide if the nonconformity is critical or not and tick appropriate box
14. Disposition	P.E. to decide on disposition, tick appropriate box and outline the details of the proposed actions.
15. Corrective/preventive action	P.E. to decide what action should be taken with the design, the manufacturing process, the testing procedure or any other circumstance to prevent the reoccurrence of the problem.
16. Approval of non critical nonconformities	Complete with the name of the Project Engineer and the date of approval.
17. Approval of critical nonconformities	Complete with the name of the Project Manager, the name of the approval list if appropriate, and the date of approval.
18. Closure of the nonconformity	For a non critical NC, complete with the name of the Quality Manager and the date of the verification. For a critical NC, complete with the name of the CERN Project Engineer and the date of the verification.

Note that points 16, 17 and 18 may be left blank for all nonconformities that are tracked using the EDMS system as described in chapter 3 of document LHC-PM-QA-611.00 "Management of Nonconformities"